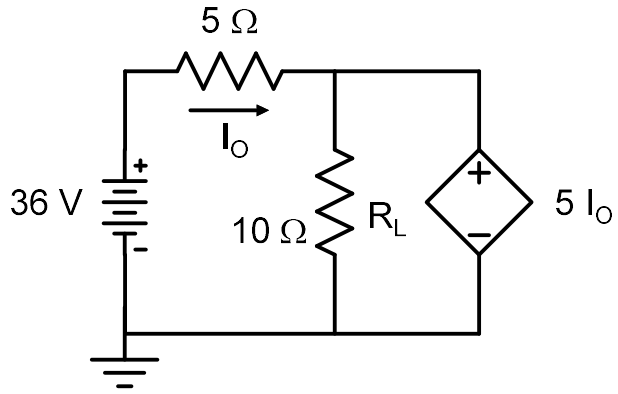
ESC201T : Introduction to Electronics

HW2: Solution

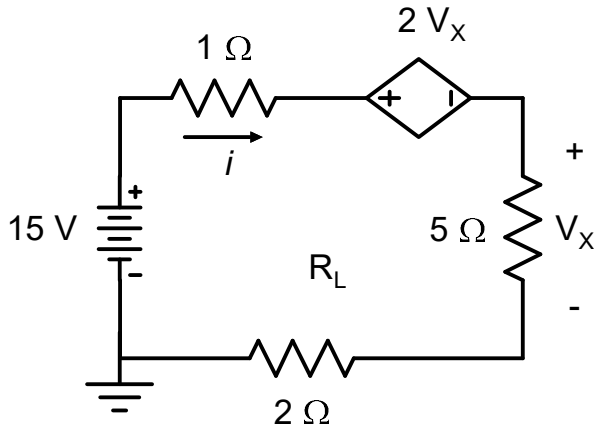
B. Mazhari
Dept. of EE, IIT Kanpur

Q.1 Determine the unknown current and voltage in the circuits shown below



$$-36 + 5 \times I_O + 5 \times I_O = 0$$

$$\Rightarrow I_O = 3.6A$$

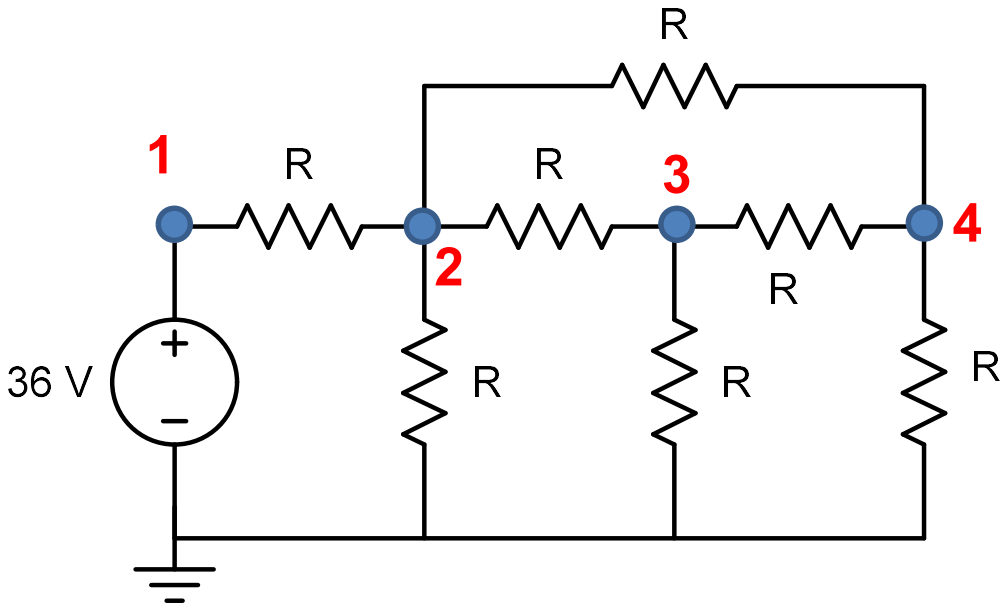


$$-15 + i + 2v_x + 5i + 2i = 0$$

$$v_x = 5i$$

$$\Rightarrow \; i = 15/18 \; A \; ; \; v_x = 75/18 \; V$$

Q.2 Apply the method of nodal analysis to the circuit shown on the right and write down the set of equations in terms of unknown nodal voltages.



$$v_1 = 36V$$

Node 2:

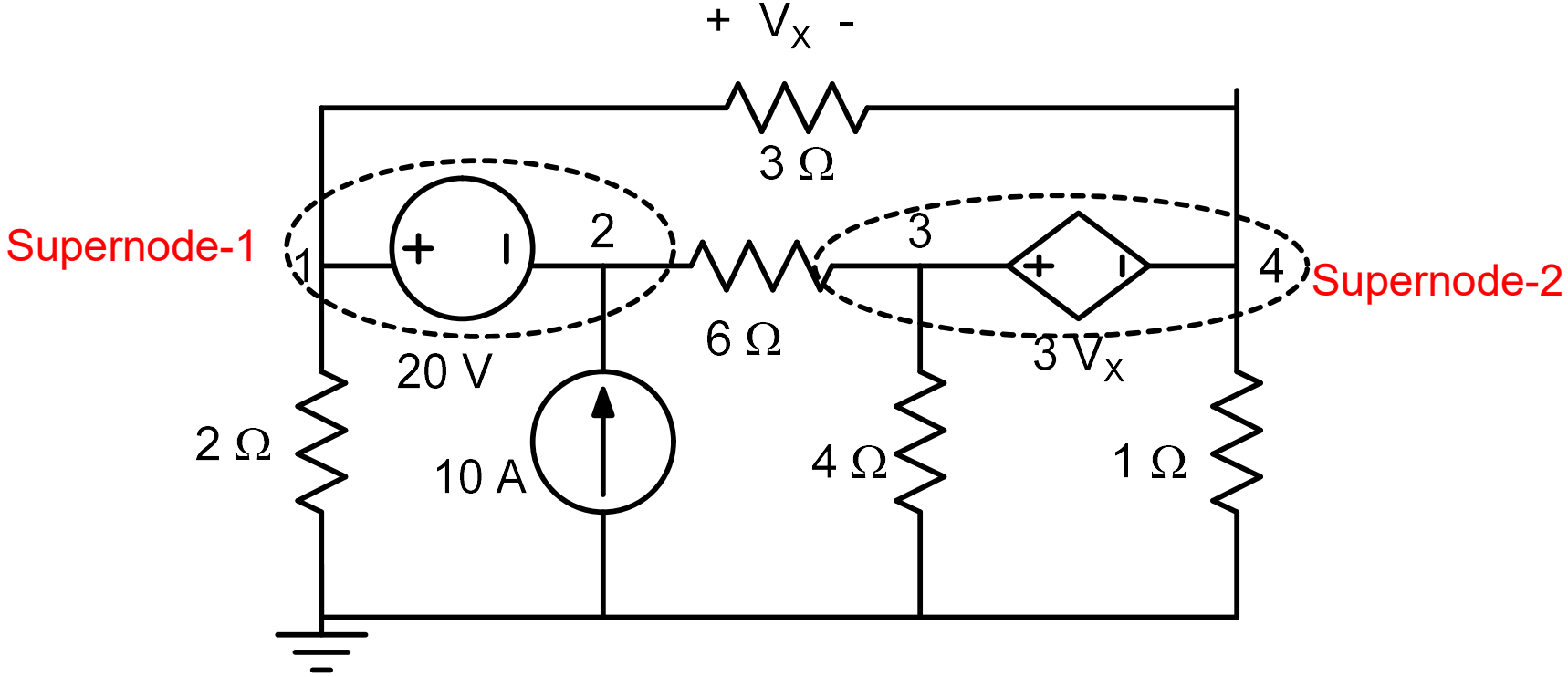
$$\frac{v_2 - v_1}{R} + \frac{v_2}{R} + \frac{v_2 - v_3}{R} + \frac{v_2 - v_4}{R} = 0$$

Node 3:

$$\frac{v_3 - v_2}{R} + \frac{v_3}{R} + \frac{v_3 - v_4}{R} = 0$$

Node 4: $$\frac{v_4 - v_3}{R} + \frac{v_4}{R} + \frac{v_4 - v_2}{R} = 0$$

Q.3 Write down the equations for the node voltages using the method of nodal analysis for the circuit shown below. Use the concept of super node.

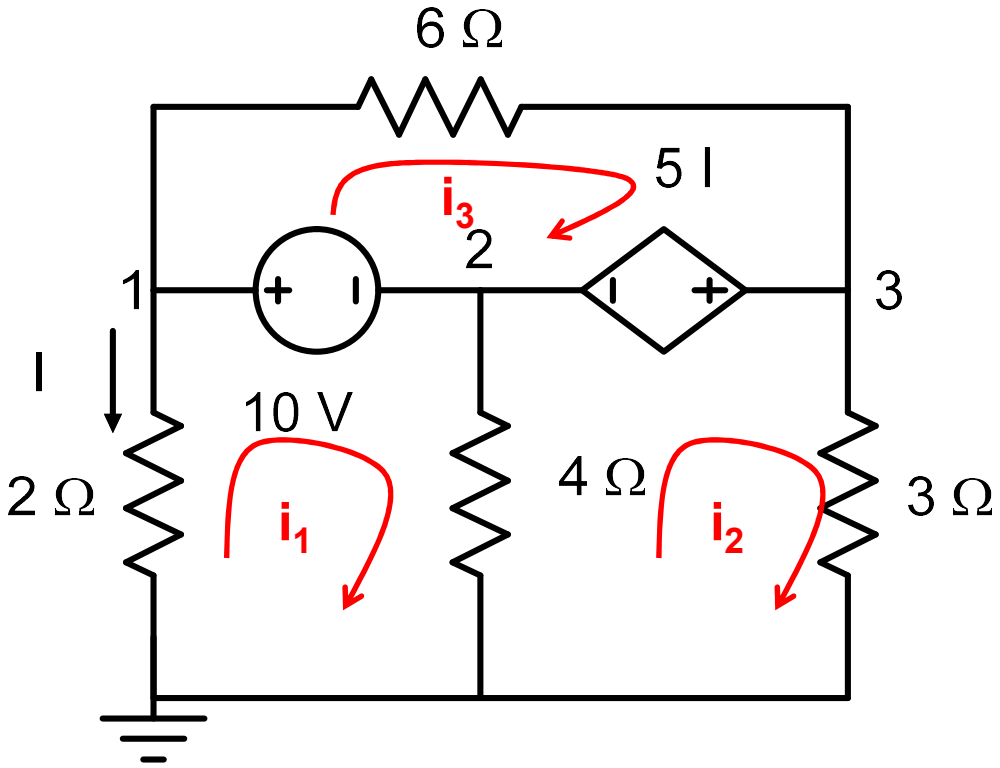


Supernode-1 $$\frac{V_1 - 0}{2} + \frac{V_1 - V_4}{3} + \frac{V_2 - V_3}{6} - 10 = 0$$

Supernode-2 $$\frac{V_3 - 0}{4} + \frac{V_3 - V_2}{6} + \frac{V_4 - 0}{1} + \frac{V_4 - V_1}{3} = 0$$

$$V_1 - V_2 = 20 \qquad V_3 - V_4 = 3v_x = 3 \times (V_1 - V_4)$$

Q.4 Apply mesh analysis to the circuit shown below



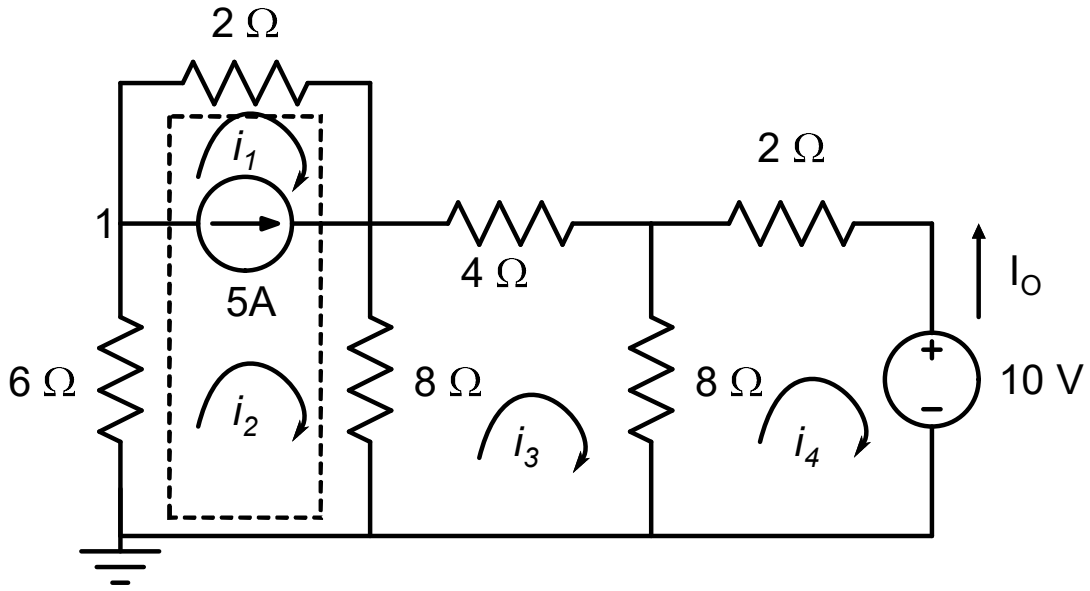
Mesh-1 $2i_1 + 10 + 4(i_1 - i_2) = 0$

Mesh-2 $4(i_2 - i_1) - 5i + 3i_2 = 0$

$i = -i_1$

Mesh-3 $6i_3 + 5i - 10 = 0$

Q.5 Use the concept of super-mesh to solve the circuit shown below



Supermesh $2i_1 + 8(i_2 - i_3) + 6i_2 = 0$ $i_2 - i_1 = 5$

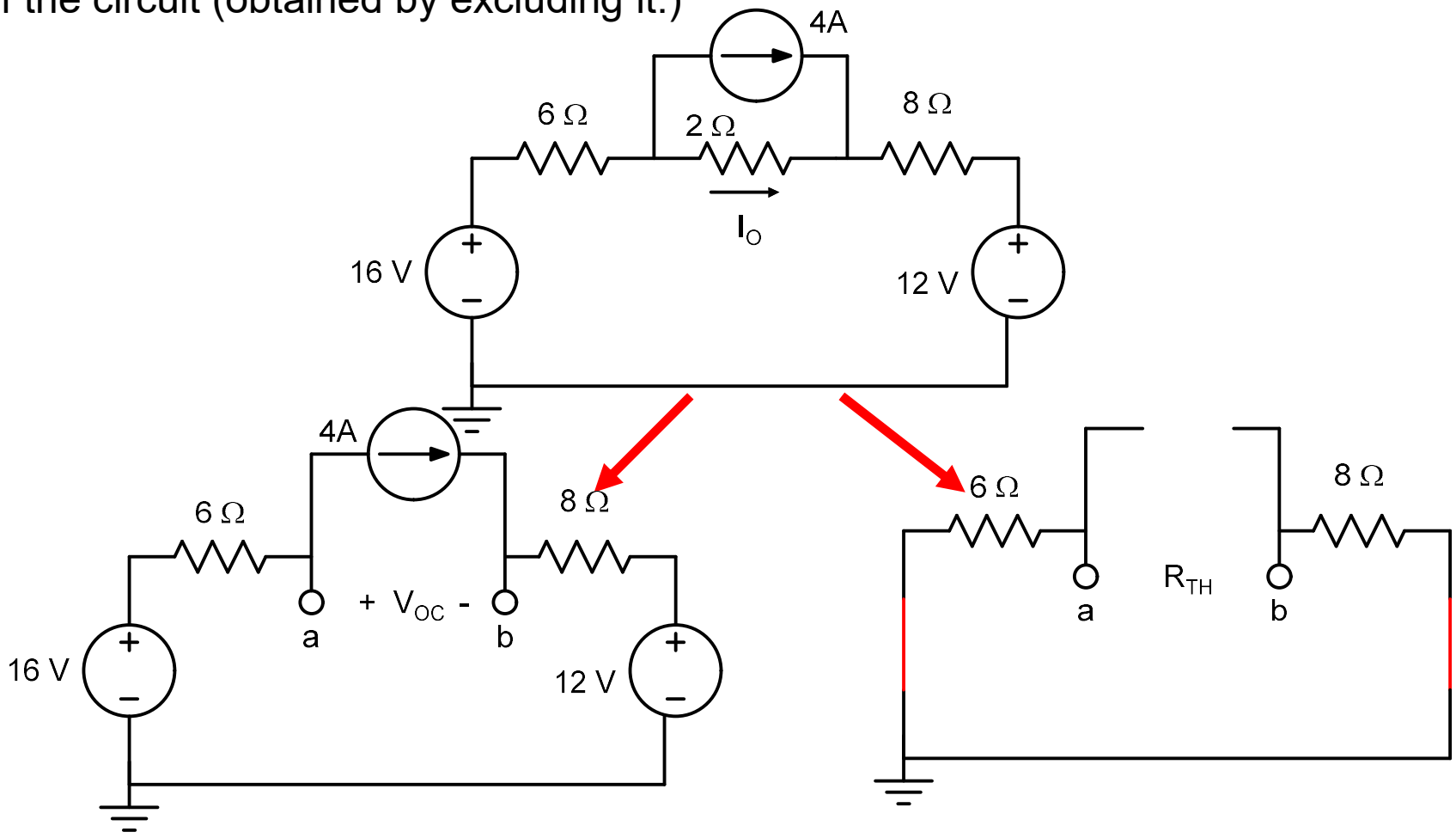
Mesh-3 $4i_3 + 8(i_3 - i_4) + 8(i_3 - i_2) = 0$

$I_O = -i_4$

Mesh-4 $2i_4 + 10 + 8(i_4 - i_3) = 0$

$i_1 = -4.53A; i_2 = 0.468A; i_3 = -0.31A; i_4 = -1.25A$

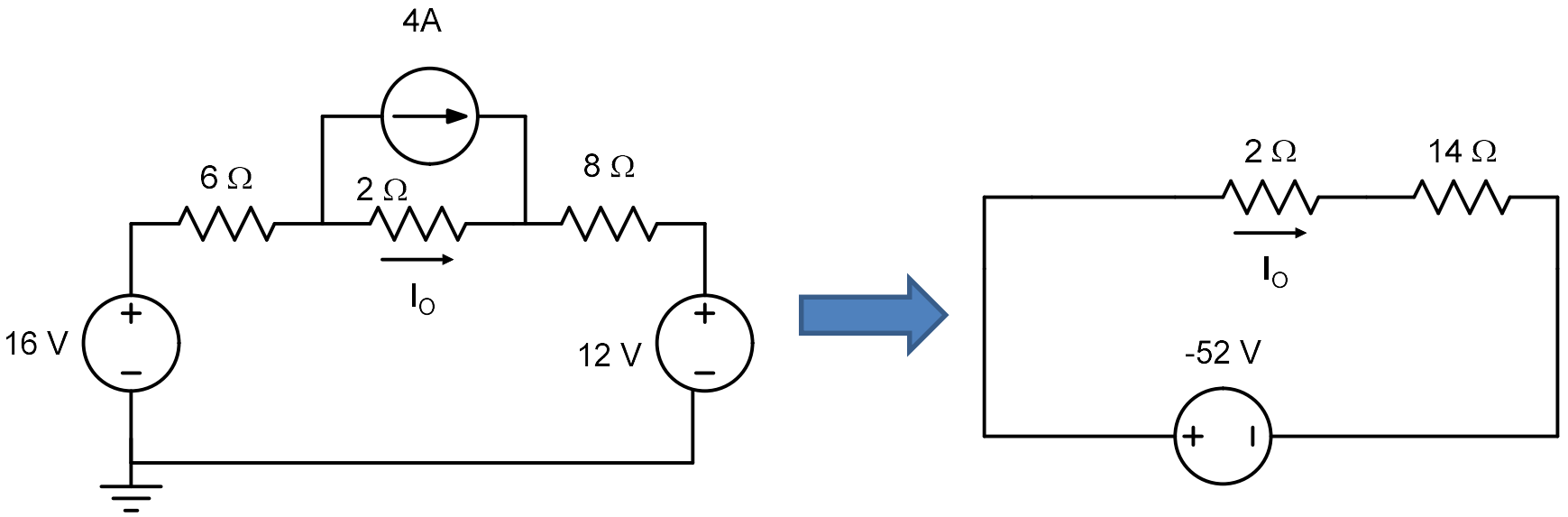
Q.6 Determine current in 2Ω resistor by building Thevenin's equivalent for the rest of the circuit (obtained by excluding it.)



$$-16 + 4 \times 6 + v_{OC} + 4 \times 8 + 12 = 0$$

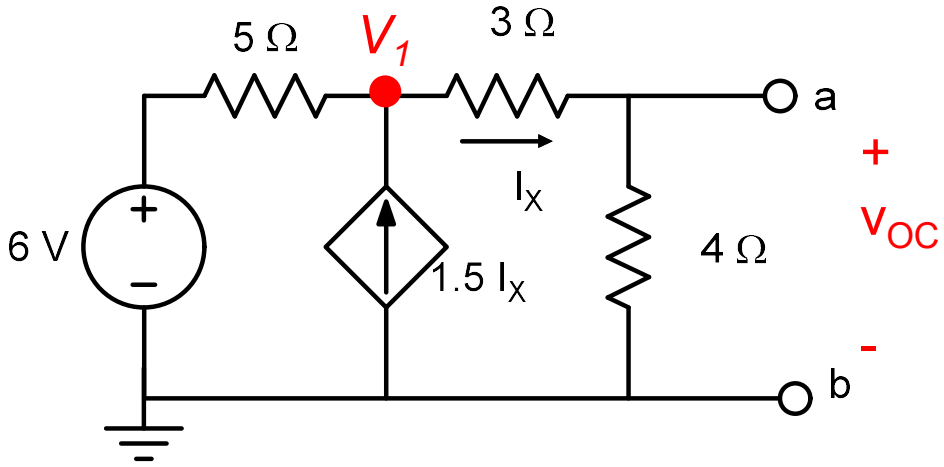
$$v_{OC} = -52V$$

$$R_t = 14\Omega$$



$$52 + I_O \times 16 = 0 \Rightarrow I_O = -3.25A$$

Q.7 Determine Norton's equivalent for the circuit shown below

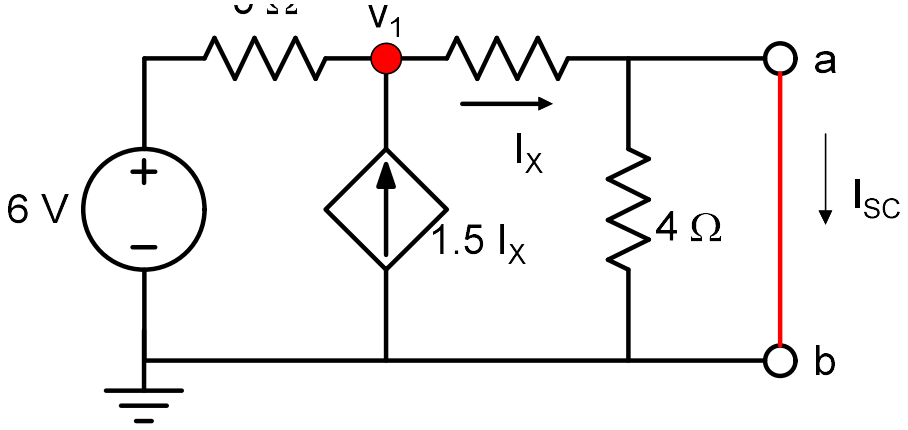


$$\frac{v_1 - 6}{5} - 1.5I_x + I_x = 0 \ (1)$$

$$\frac{v_{oc} - v_1}{3} + \frac{v_{oc}}{4} = 0 \ (2)$$

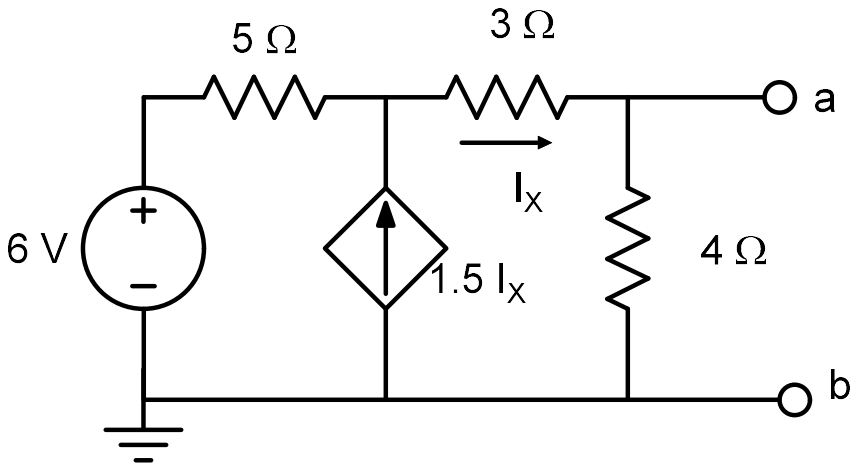
$$I_x = \frac{v_{oc}}{4} \ (3)$$

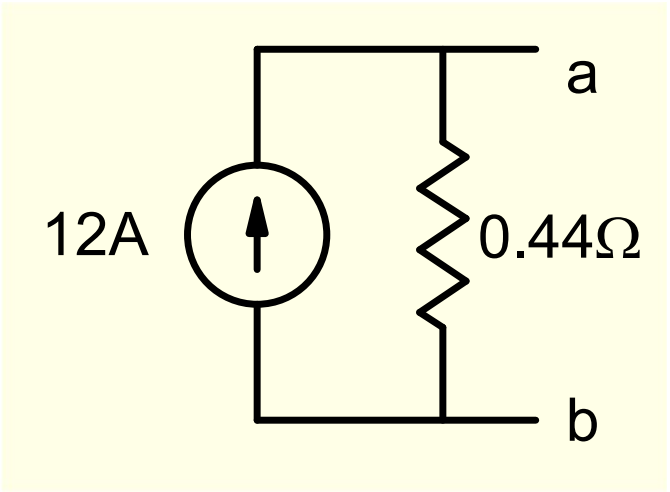
$$\Rightarrow \ v_{oc} = 5.33V$$



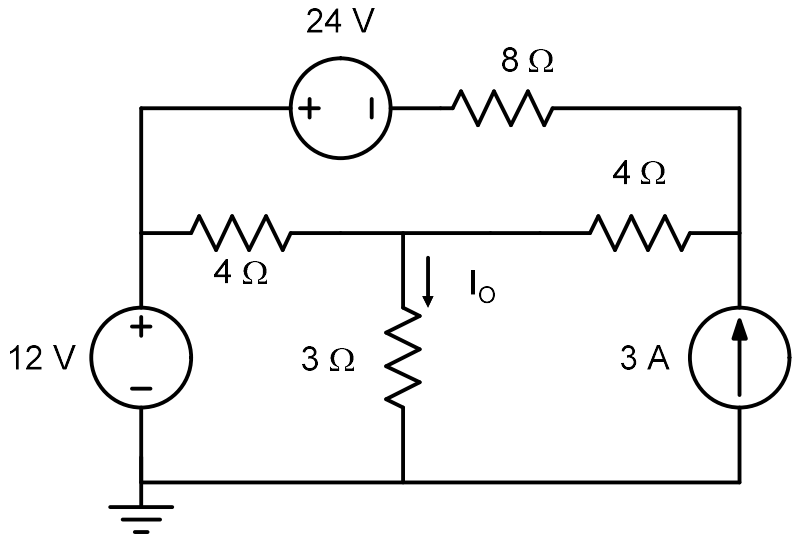
$$\frac{v_1 - 6}{5} - 1.5I_x + I_x = 0 \qquad I_x = i_{sc} = \frac{v_1}{3} \qquad i_{sc} = 12\,A$$

$$R_N = \frac{v_{oc}}{i_{sc}} = 0.44\Omega$$

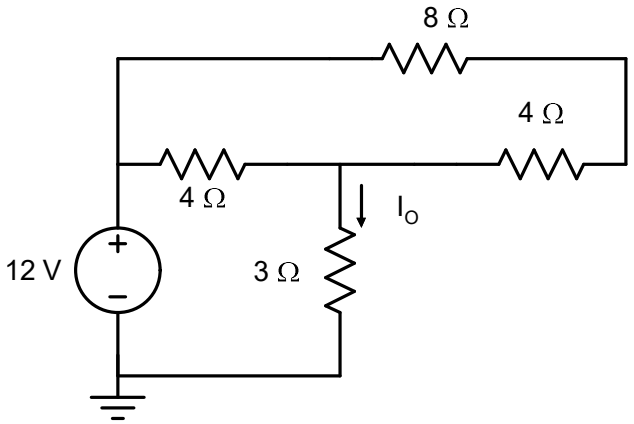


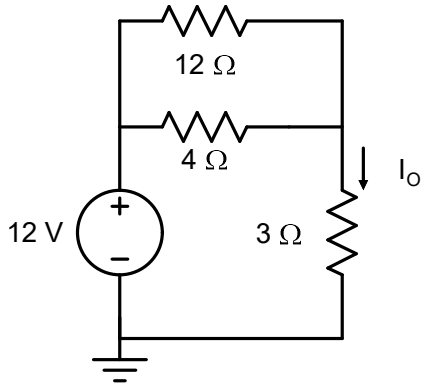


Q.8 Use superposition theorem to solve for current *i* in the circuit shown below

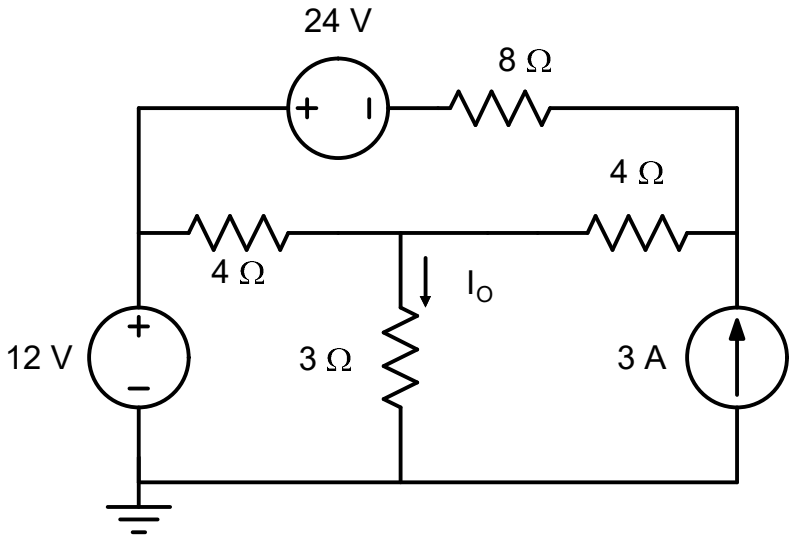


Find current due to 12V source only

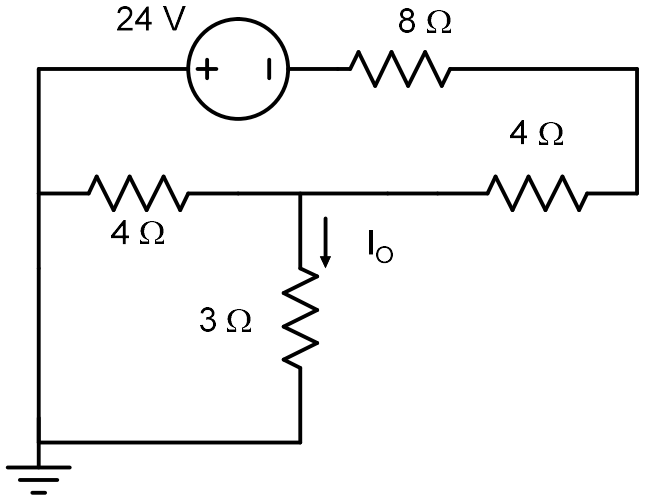


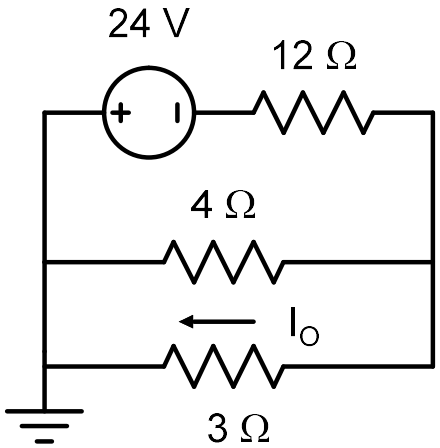


$$I_O = 2A$$

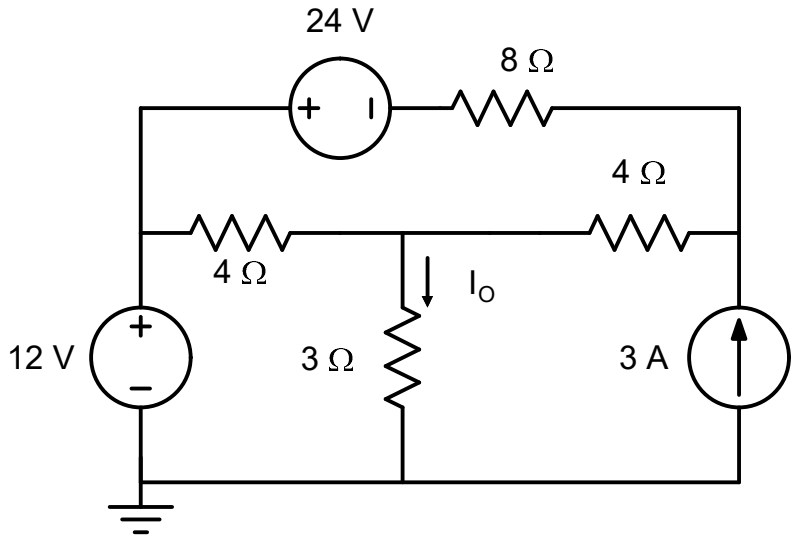


Find current due to 24V source only

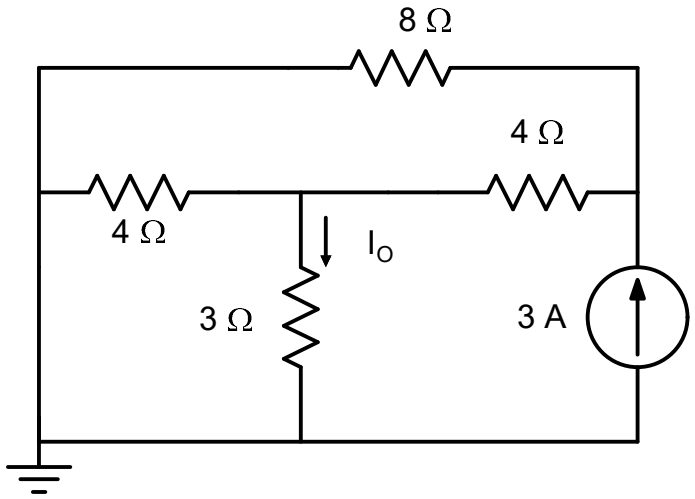


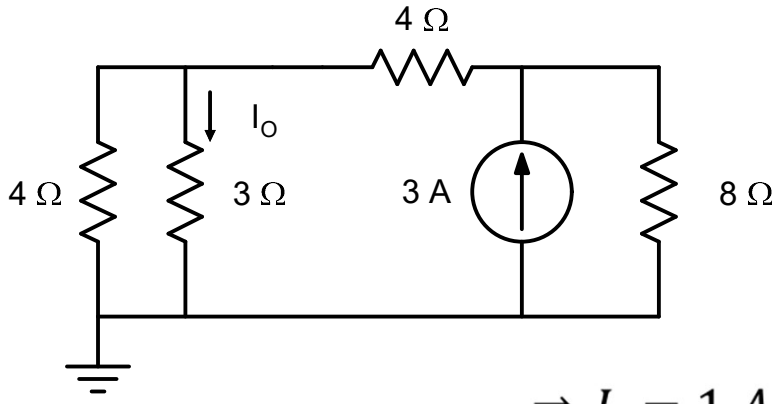


$$I_O = -1\ A$$



Find current due to 3A source only

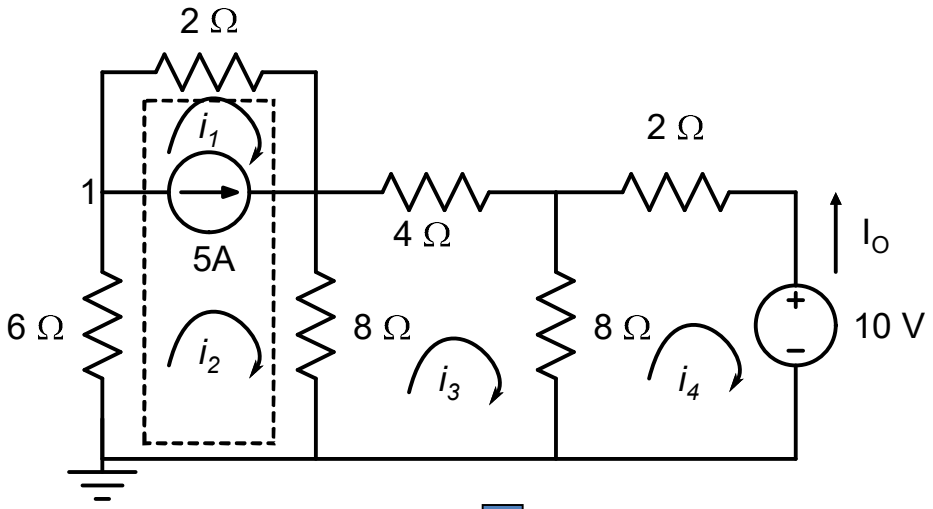


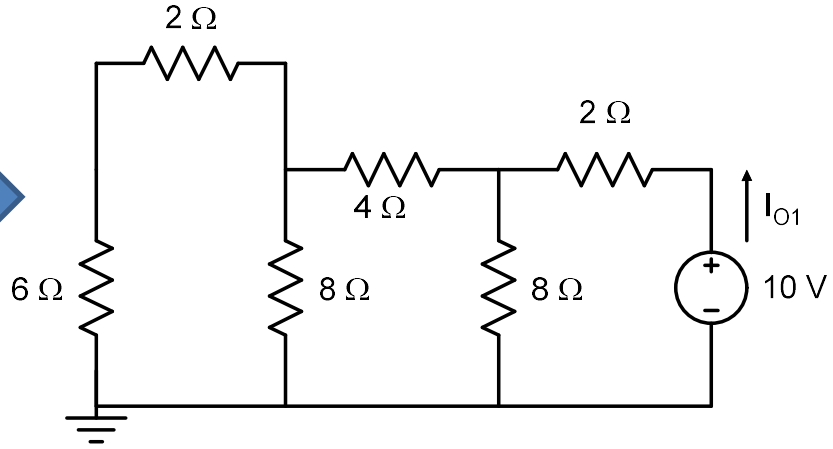


$\Rightarrow I_O = 1\ A$

Net current = $2 - 1 + 1 = 2A$

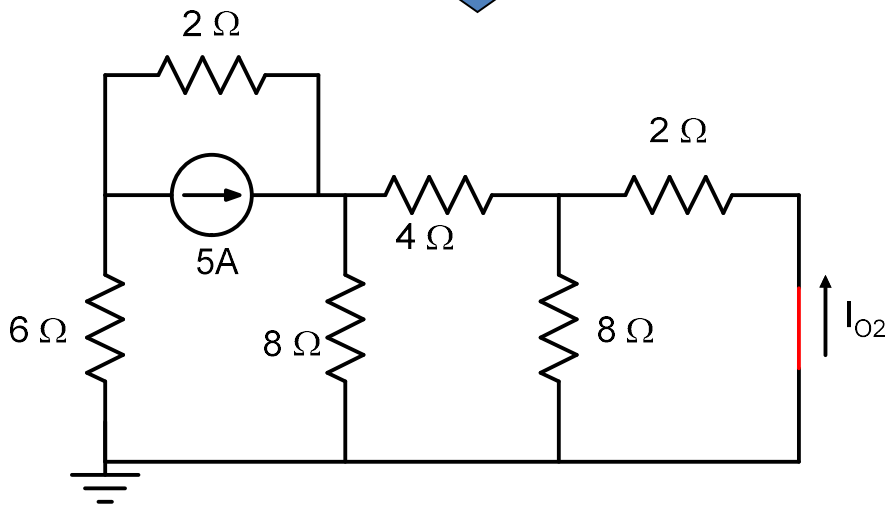
Q.9 Use superposition theorem to solve the circuit of Q.5





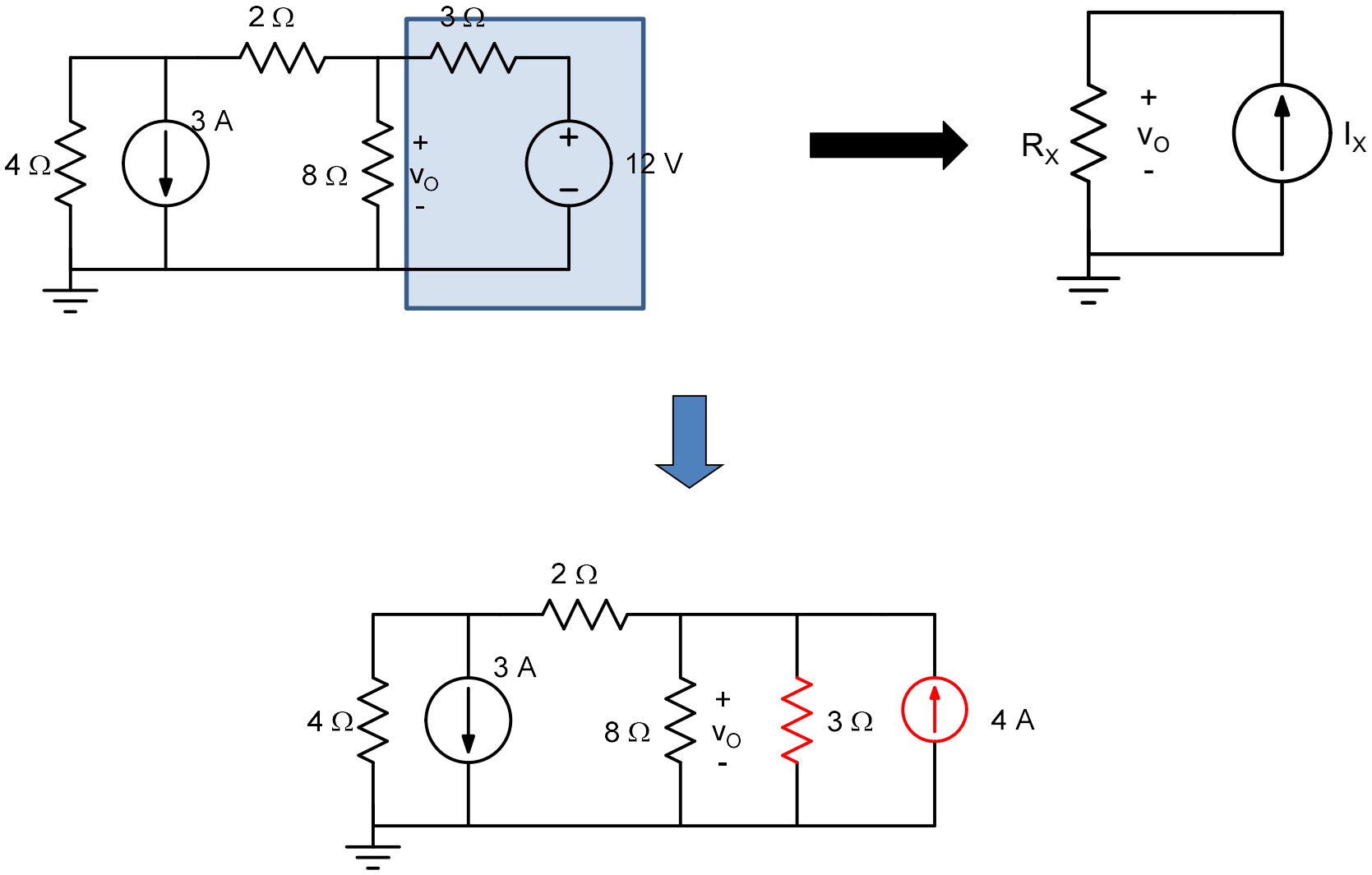
$$I_O = I_{O1} + I_{O2}$$

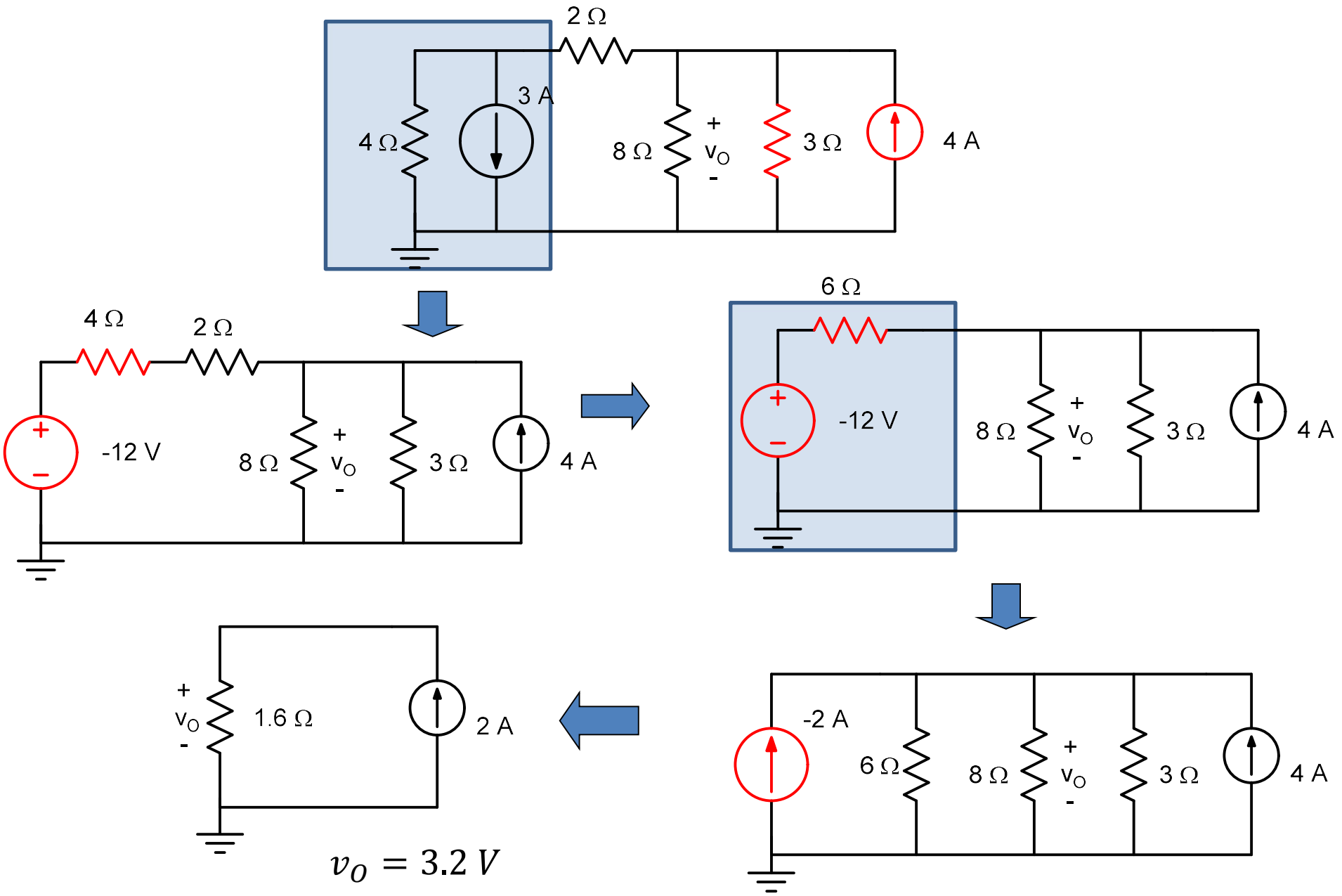
$$I_{O1} = \frac{10}{6} = 1.66\text{A}$$



$$I_{O2} = -0.416\,A \Rightarrow I_O = 1.24A$$

Q.10 Apply source transformation repeatedly to transform the circuit shown below on the left into the simplified circuit shown on the right. Determine the value of current I_x and resistance R_x and use it to determine to obtain the voltage v_o .




2 Ω
3 A
4 Ω
8 Ω
+
v_O
-
3 Ω
4 A
4 Ω
2 Ω
-12 V
8 Ω
+
v_O
-
3 Ω
4 A
6 Ω
-12 V
8 Ω
+
v_O
-
3 Ω
4 A
-2 A
6 Ω
8 Ω
+
v_O
-
3 Ω
4 A
+
v_O
-
1.6 Ω
2 A

$$v_o = 3.2\ V$$